Methods of Locust Control recommended by the Imperial Council of Agricultural Research

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The aim of locust control operations is to destroy all locusts rather than protect individual areas of crops The operations to be effective must prevent another generation reaching the flying stage. It is no solution of the problem to move locusts on to adjoining areas.

Control operations can be carried out against the locust in all stages of its life history.

Flying locusts.—This is obviously the most difficult stage at which to deal with locusts and complete control during this stage cannot be expected. But by the measures described below much can be done.

(*a*) *By night*—when the locusts are collected on crops or trees and are sluggish at night or the early morning,

(1) on bare ground, they can be beaten or swept up,

(2) when the locusts have settled on bushes or hedges especially on waste land, they can be burnt [Method 1 (*a*), Appendix],

(3) on valuable trees, they can be shaken down and destroyed,

(4) when the locusts are resting on crops, they can be collected by hand and destroyed.

(*b*) *By day*—when locusts have settled on crops or waste land to feed they are often easily disturbed, but if not they can be dealt with by the use of insecticidal baits, (Method 4 Appendix.)

(*c*) Locusts usually pair on fallow or waste land or sandy soil where they will lay eggs. During pairing they can be destroyed by crushing or burning.

(*d*) When actually laying eggs, the females are still more easily destroyed by crushing.

The result of these methods will be progressively to reduce the size of the swarms before they lay eggs.

Eggs.—There appear to be two broods each year, the eggs of the first brood being laid any time between February and June and of the second brood between July and October. Whether any egg-laying occurs between November and February is not definitely known. Locusts lay their eggs in holes in the ground which they prepare to a depth of 2″ to 6″. The mass in each hole may contain from 40 to 100 eggs. The eggs will usually be found

within a well-defined area. The soundest, cheapest and most effective method of control is to prevent a new generation from hatching, or from leaving the breeding ground after hatching. Hence one of the main objects at this stage is to locate these areas with a view to organised measures of destruction.

Location of breeding grounds.—It is essential to the complete success of the campaign that all breeding grounds should be found and notified with the least possible delay. If this cannot be achieved by other means, adequate rewards should be offered for such information, especially for information regarding breeding grounds in uncultivated areas. A scale of rewards graduated according to distance from habitation, with a wide discretion to the District Officer, is worth consideration.

Control measures at breeding grounds.—(1) When a breeding ground is located, the first step is to ring it by a method suitable to the soil (Method 2, Appendix).

(2) The actual method used will depend on the nature of the soil: generally trenching is the simplest and cheapest. It is important that the work shall be thoroughly done hence payment for supervision and any essential labour would be fully justified. It is important that breeding grounds in remote places or on difficult soil should not be neglected.

Egg destruction.—Where a breeding ground has been properly ringed, no rewards for egg destruction are necessary. But any breeding ground which, for any reason, it is not possible to ring should be dealt with by the destruction of the eggs on an organised system. Ploughing is ineffective, flooding is of limited application and must be protracted. The digging out and destruction of the egg-masses is effective—so far as it goes—but always leaves behind a large number of eggs to produce hoppers.

Cultivated plots within a ringed breeding ground.—When a ringed area includes crops or other vegetation, there are two problems:—

(*a*) To ensure that hoppers do not find sufficient food within the ringed area to enable them to leave eventually as fliers, and

(*b*) To protect the crops. The first danger can largely be met by subsidiary ringing (Method 2, Appendix) or by any of the other means recommended for hopper destruction [Method 3, 3 (*a*), 3 (*b*), Appendix].

(*c*) Crops can be protected by individual trenches surrounding the fields, the construction of which should be the duty of the cultivators themselves—but under proper supervision.

Hoppers.—Hoppers usually emerge about a fortnight after the eggs are laid. They pass through a succession of five "moults" the insect increasing in size and activity. The total length of the hopper period varies greatly but may be put at four to eight weeks according to the food supply and climatic conditions. Control measures are far more effective against young hoppers before the second moult than subsequently and also much easier.

Methods for the destruction of hoppers may be either chemical or mechanical.

Chemical—Contact insecticides—as distinct from stomach insecticides.

Many satisfactory, though expensive, contact insecticides, are known but their use on a wide scale in India is not immediately practicable. (See however for their use in special circumstances Method 3, Appendix.)

Stomach insecticides (which act through being eaten).

(*a*) *Baits.*—Of these the most applicable to Indian conditions is sodium fluosilicate which is deadly to locusts but has been shown by actual experiments in India to be innocuous to domestic animals—even in far larger doses than could possibly be consumed by a grazing animal. Locusts will greedily eat certain baits, *e.g.*, moist bran; to this 2 per cent. of the insecticide is added which is sufficient to kill the locusts. Details are given in the Appendix. The only risk in the wide distribution of this insecticide is that it may not be kept with proper care and may be mistaken for a harmless substance. It is recommended, therefore, that it should be coloured with some suitable dye and its issue, except as a prepared bait, limited to responsible officials. The preparation of the baits should be carried on under official supervision (Method 4, Appendix).

(*b*) *Dusting or spraying.*—Sodium fluosilicate is also suitable for direct application to crops or wild vegetation where other methods may not be feasible. This method would only be used by a trained man who could be trusted both to supervise the apparatus and control the operations and supply of insecticide. (See Method 5, Appendix.)

Cost.—The cost of sodium fluosilicate landed in Calcutta is about Rs. 14 per cwt.

Mechanical Methods.—The principal mechanical method of dealing with moving bands of hoppers is to use trenches into which the bands of hoppers are driven. [See Method 6 (*a*), Appendix.] In the initial stages and on favourable soil, trenches are sufficient—but their efficiency is greatly increased by the use of side screens to guide the bands and prevent them breaking away. Where it is found in practice that plain trenches do not retain the hoppers, a six-inch strip of *shiny-surfaced* oil-cloth can be affixed to the walls

of the trench. This method of reinforcing trenches has been proved to prevent the hoppers from leaving the trenches. The oil-cloth costs about Rs. 2 per yard 48" wide. [See Method 6 (*b*), Appendix.]

Canvas traps.—Where the nature of the ground precludes trench digging, canvas traps can be used.

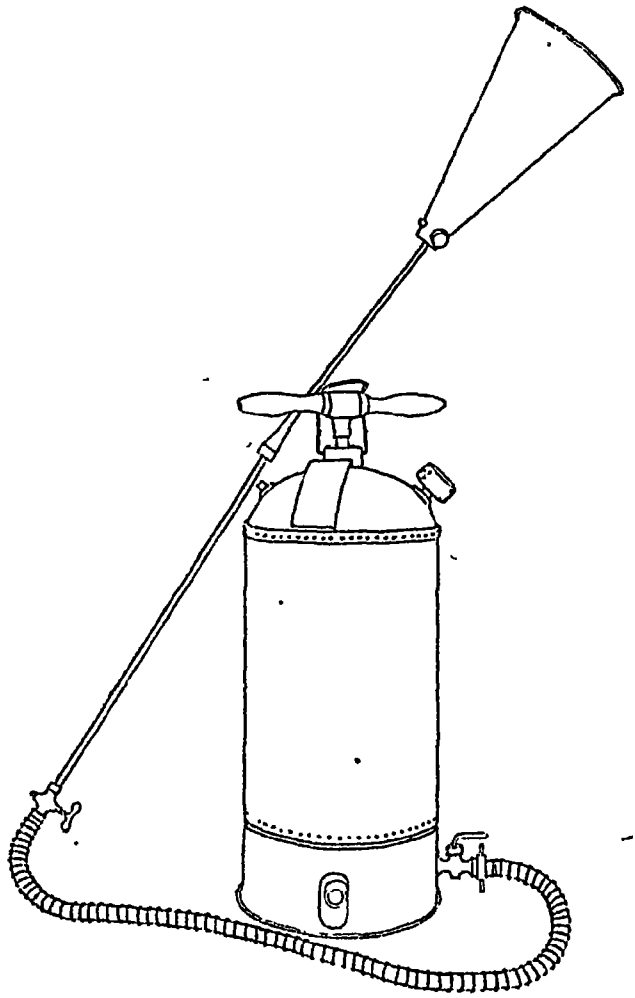
Water.—Pools, ditches containing water and old *kachcha* wells may be utilised (where available) in lieu of trenches. Oil is usually required to kill locusts driven on to water.

Side-screens.—These can be prepared from lengths of any cloth, provided a six-inch strip of oil-cloth is attached along its length near the upper edge. The screens are suspended from upright iron rods, sharpened at the lower end and bent into a hook at the upper. (See Method 7, Appendix.)

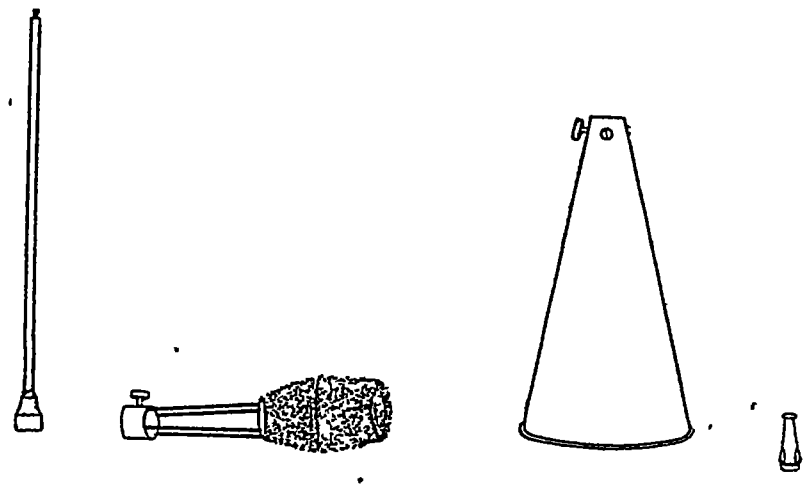
Control measures—General.

Biological methods.—Birds which eat locusts, *e g.*, Mynahs, starlings (*Punjabi Tilliar*) should be protected. Other biological methods which have been suggested, *e g.*, bacterial and fungal diseases do not so far offer any practical solution.

2. When locusts attack canal-irrigated areas it has been found advantageous for all canals to run at full supply.



FLAME-PROJECTOR COMPLETE



COMPONENT PARTS OF CONE ADAPTOR FOR FLAME-PROJECTING APPARATUS.

APPENDIX.

(DETAILS OF CONTROL METHODS).

DESTRUCTION OF FLYING LOCUSTS.

Method 1(a).—Burning.

Flying locusts densely congregated on dry herbage at night.—Set fire to dry herbage, bushes, useless hedges, etc. If these are not sufficiently dry to fire readily, sprinkle first with mineral oil which will facilitate the operation. This method is advisable only on cold nights with a temperature not exceeding 65°F.

Method 1(b).—Flame throwers.

Flying locusts densely congregated on green bushes, trees and hedges.—Where a trained staff equipped with flame throwers is available they can be used to advantage to destroy Locusts which have settled on green bushes, hedges and trees which cannot be set fire to. Flame throwers should be operated in the early morning but not at night. A flame thrower consists of a pressure chamber of the knapsack sprayer type containing the fuel, which may be a mixture of crude mineral oil and kerosene oil, or crude mineral oil and petrol. The fuel is ejected under pressure through a flexible metal pipe continued into a metal tube with a fine jet. A special form of vapouriser is necessary to ensure the projection of an effective flame. **This method should only be used under skilled supervision with approved apparatus.** (See Illustrations on pages 5 and 6.)

This method is applicable to adult locusts settled for resting, irrespective of the temperature. It is also applicable to swarms which are in the act of pairing or of egg-laying.

OPERATIONS AGAINST AREAS IN WHICH EGGS HAVE BEEN LAID.

Method 2.—Ringing of breeding grounds.

Determine the outer limits of the breeding ground and mark them out and make effective arrangements to prevent emerging hoppers from leaving the breeding area by surrounding it completely with a trench or a raised barrier which the young locusts will not be able to cross. Very large breeding grounds will require to be divided by cross trenches. No definite spacing can be laid down and the position and number of cross trenches must be left to the judgment of the officer in charge of the operations. It is suggested that they should never be more than one mile apart—preferably much closer. Their lay-out will take into consideration patches of jungle or cultivated areas within the ring-trenched area which might provide sufficient food to maintain the hoppers throughout their development.

Fields under crop within the breeding ground should be trenched around by the occupiers of the fields under proper supervision.

For the small hoppers which come out of the eggs a very deep or very wide trench is not necessary. If, however, it is expected that the numbers of hoppers will be so great that a small trench will not contain them dig deep pits at intervals along the trench into which the hoppers can fall or be swept.

Method 2(a).—Ring trenches—Plain.

If the soil is suitable dig a trench at least one foot wide and eighteen inches deep all round the breeding ground before the young hoppers have emerged from the eggs. The trench walls should be vertical or under-cut, and the walls must be free from projections or rough surfaces unless other means are employed to prevent the hoppers from climbing up and escaping.

Ring trenches—Reinforced.

Method 2(b).—(i) With oil-cloth.

Strips of shiny American oil-cloth six inches in width nailed along the top six inches of the outer wall of the trench effectively prevent any hoppers from escaping. The oil-cloth strip requires to be carefully affixed by nails near the top and bottom edges and to be applied to the outside wall of the trench, so that the top of the strip of oil-cloth is as near to the ground level as is convenient. It is advisable to cut the wall of the trench as straight as possible in order that the oil-cloth strip, can be easily affixed and so that there are no gaps between it and the earth of the wall through which the young locusts could escape

Method 2(b).—(ii) With metal sheets.

Sheets of smooth metal, *e g* ; sides of kerosene-oil tins, one foot in width laid so as to overhang the outer edge of the trench similarly prevent the escaping of hoppers.

Method 2(c).—Ring fencing.

When the soil does not allow effective trench-digging, the hoppers may be kept inside the breeding ground by ring-fencing The ring-fencing may consist of oil-cloth strips or metal sheets

If pits can be dug along the ring-fence, these should be prepared, so that hoppers moving along the inside of the fence will fall into them. If the ground is not suitable for the digging of pits, the young hoppers may either be left to starve or may be destroyed by methods detailed under " Destruction of Hoppers ".

Method 2(c).—(i) With oil-cloth.

Oil-cloth strips, six inches wide, erected to form a continuous vertical fence, will prevent young locust hoppers from escaping, but the oil-cloth requires to be very carefully erected so that no hoppers

can escape between its lower edge and the ground. Stout tapes in pairs should be sewn at six feet apart along the back of the oil-cloth strip. One of these will be near the top edge and the other at one inch from the bottom edge. By these tapes the oil-cloth will be tied to and supported by iron spikes of round bar iron of one foot length. In fixing the oil-cloth to the stakes it will be essential that the bottom edge of the oil-cloth is lying on the ground, leaving no space.

Method 2(c).—(ii) With metal sheets.

Sheets of zinc, plain galvanised iron, or tin, cut in long strips of one foot wide, serve as very efficient fencing. They have the disadvantage of being heavier to transport and slower to erect than oil-cloth strips, but last better and may be more easily obtainable locally. The metal sheets are erected vertically in a continuous line and are maintained in position by iron spikes in pairs in front of and behind the metal sheeting. The iron spikes, when in position, must not reach to more than half the height of the metal sheeting or they will afford a means of exit to the hoppers. The metal sheets must everywhere be in close contact with the soil, and to ensure this it may be necessary to dig a shallow groove, replacing the earth against the sheets when in position.

Maintenance of ring trenches or ring fences.

As the ring trenches may require to be dug expeditiously after the location of breeding grounds, and may have to be in commission for a considerable time, it will be necessary to provide patrols for repairing damage caused by animals, and to see that the oil-cloth remains in position. One labourer will be able to look after a considerable length of trench until the hoppers are on the move.

DESTRUCTION OF HOPPERS.

Method 3.—Contact insecticides.

Cheap kerosene oil is deadly to young locusts if it is brought into contact with the insect's skin. It is, however, expensive to use as a general method of control, and should generally be employed only to destroy accumulations of hoppers in trenches or pits which may require to be emptied for further use. Economy in its use may be effected by mixing the kerosene oil with soap.

Method 3(a).—Soft soap—Kerosene emulsion.

Mix the kerosene with soft soap by a wooden paddle stirring vigorously until no more kerosene will go into the mixture. A jelly-like mass will result which can then be mixed with water in the proportion of four gallons of water to one gallon of the kerosene oil used.

Method 3(b).—Hard soap—Kerosene emulsion.

Cut a bar of hard soap into thin slices and dissolve in the minimum quantity of boiling water. Add the kerosene oil and mix stirring vigorously and warming if necessary and use as in (a).

Pesterine, which is a mixture of oils is more effective than Kerosene and is slightly cheaper than kerosene if obtained in bulk. It is not, however, available without making special arrangements for supply. If used, it should be employed in the same way as kerosene oil.

Syringes or other apparatus for distributing kerosene and pesterine or emulsion of these should not have rubber washers or other parts as the oil rots the rubber.

Method 4.—Insecticidal Bait—Preparation.

The bait consists of four component parts:—

(*a*) The insecticide.

(*b*) The carrier: which is the material into which the insecticide is mixed.

(*c*) Water.

(*d*) *An attractant: which makes the bait more attractive* to the locusts.

(*a*) The Insecticide.—The substance to be used is Sodium fluosilicate. This is a white powder. It is fatal to locusts even in very small quantities. It is not poisonous to animals in small quantities but must be considered harmful in quantities of a tola or above. It should therefore be treated with the same care as if it were a poison.

(*b*) The Carrier.—The most suitable material to use as a carrier is WHEAT BRAN or RICE BRAN. Other substances which may be used are cotton-seed meal, saw-dust, horse dung, flour mill sweepings. The purpose of the carrier is to provide a material into which the insecticide can be readily mixed so that it can easily be scattered very thinly over the ground.

Experiments with other locally available material should be made where possible. Oil mill residues may prove suitable.

(*c*) The baits must be used moist.

(*d*) The Attractant.—Molasses, rab or gur, Amyl acetate, Salt.

Proportions.

Formula No. I.

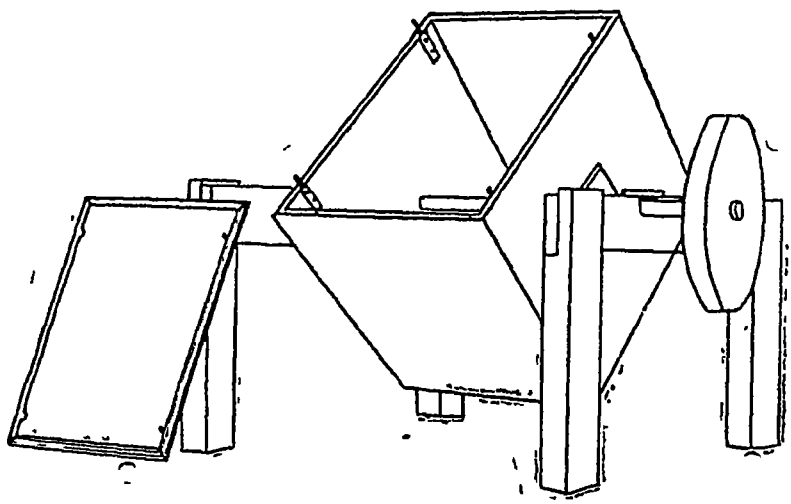
Bran	.. 50 seers.
Sodium fluosilicate	.. 1 seer.
Molasses, gur or rab	.. 2 seers,
Water	.. As required.

Formula No. II.

Bran	.. 50 seers.
Sodium fluosilicate	.. 1 seer.
Salt	.. 1 „
Water	.. As required.

Amyl acetate may be added to either mixture at the rate of one chhatak per 50 seers if this material is available. It is not considered essential but it does attract locusts to the bait.

Preparation.—The carrier and the insecticide should be mixed in the dry state, either by hand on a clean floor or by preparing a rotating box into which the ingredients are placed and the box rotated until thoroughly mixed. The molasses or gur or other attractants are dissolved in the minimum of water and are then added to the mixture. Further water is added until the bait becomes moist and crumbly but not so wet as to be sticky and to adhere in lumps.



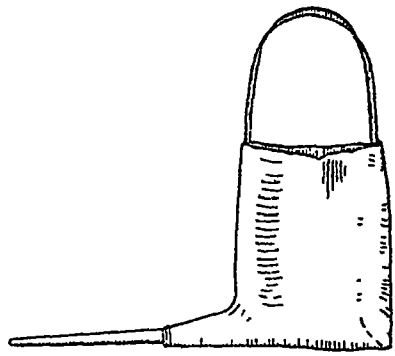
BAIT MIXER.

Bulk mixing, storage, and distribution.—It is recommended that insecticidal bait should be prepared at centres by a responsible officer. It is essential that the bait should be moist when used and it is suggested that kerosene oil tins should be utilised for storage and distribution.

INSECTICIDAL BAITS—USE

Method of scattering.—SCATTER THE BAIT VERY THINLY AND AS EVENLY AS POSSIBLE. It can be broadcast by hand without any special apparatus but it is convenient to use a bag of the shape illustrated which is made of leather or canvas. The outlet is in the form of a sleeve into which is fitted a tube of tin or galvanised iron about two feet long, two and a half inches in diameter

at the upper end, and one and five-eighths inches at the lower. Ove the mouth of the tube, two curved cross wires are soldered crossing at right angles. The operator swings the tube backward and forward, thus broadcasting the contents of the bag and causing the bait to break in small pieces as it leaves the tube.



BAIT DISTRIBUTOR

Bhistis *mashaks* should be easily adaptable to the purpose and also old grain sacks.

Use of baits against fliers.—When flying swarms have descended to feed, the bait should be scattered throughout the area with as little disturbance of the swarm as possible. The early morning is the best time to scatter bait as it is most effective while it retains its moisture. From ten to twenty five seers should be scattered per acre according to the density of the swarm.

Use of baits against hoppers.—Against hopper bands, the bait should be scattered in the early morning over the band of hoppers and also on a belt in advance of the line of movement. The width of the belt depends upon the size of the swarm as it is necessary that there should be room for all the individuals to feed on the bait. The depth of the band from front to back and the density of the swarm must guide the operator in estimating the requisite width, of the belt over which the bait is to be broadcast.

Method 5.—Dusting or spraying crops and wild vegetation with insecticide.

Dusting has the advantage over spraying of being independent of water supplies, and when the necessary apparatus is available should be the principal method for employment upon swarms in extensive areas under heavy crop or large swarms in scrub vegetation.

Method 5(a)(i).—Dusting.

Hand powder-guns* (cost about Rs. 40 each) of the knapsack type are capable only of dealing with comparatively small areas (one to two acres per day) and require suitable weather conditions to develop their maximum efficiency. The insecticide is distributed in a blast of air, and is carried by air currents on to the food plants to which it adheres if the plants are moist. In hot dry weather they can only be used effectively in the early morning or late evening, and during night.

Aeroplanes.—In other countries both aeroplanes and power powder distributors mounted on motors are successfully used for dusting large areas with insecticidal powder. As the apparatus is not at present available in India and experimental work is needed, details are not described here.

**These can be bought in India.*

Method 5(b).—Spraying.

The application of stomach insecticides in a liquid medium has a minor advantage in that the actual distribution of the insecticide within an area is under direct control.

The main disadvantage in spraying is that water must be readily available. It is also much more laborious than dusting.

With one knapsack sprayer one man can spray over one acre per day. If large areas of grass land require to be sprayed, power machines on motor vehicles should be used.

Trenches.

Method 6(a).—Plain trenches.

The efficiency of plain trenches in preventing hoppers which have got into them from getting out against depends upon the nature of the soil and the care bestowed on the preparation of the trench. In some soils plain trenches are very effective while in others they are practically useless.

The length, depth and breadth of the trenches will vary according to the size of the swarm and the stage of development of the individuals. During the first and second stages a trench, one foot wide by one and a half feet deep, with occasional pits to contain the hoppers in the case of large swarm, is adequate. The width and depth have to be increased successively in the later stages, until, in the fifth stage, a width of two and a half feet and a depth of two feet constitute the minimum.

The cross section of the trench should either be rectangular or the trench should be wider at the bottom than at the top in which case the walls overhang. With either form it is generally necessary to make the sides and ends of the trench smooth by the use of a very broad Khurpi. Particular care must be given to the ends of the trenches as the hoppers, accumulate there and escape if any foothold is available; deep and wide pits at the ends are useful.

Method 6(b).—Reinforced trenches.

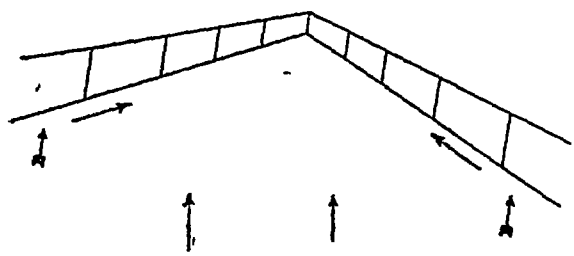
(i) Oil-cloth strips.—Locust hoppers are incapable of climbing up a vertical, smooth surface, as this allows no foothold. The most satisfactory material so far employed is smooth American oil-cloth. This is less liable to damage than glazed paper or tracing cloth and on a large scale is much more easily transported and placed in position than metal strips.

A six-inch strip of oil-cloth greatly reduces the labour of trench digging as the lower portion of the trench need then only be roughly dug. The top six-inches are cut straight vertical, and fairly smooth, and the oil-cloth is nailed along this. Hoppers driven into such a trench find escape quite impossible, so that stops on the far side of the trench are not needed, and the advance of the swarm is not checked unnecessarily.

(ii) Metal sheets.—Metal sheets laid on the ground so as to overhang the sides and ends of the trenches also prevent the escape of hoppers. The metal on the approach side should be covered with earth.

Method 7.—Locust screens and barriers.

The simple method of driving hopper bands into pits or trenches using lines of people as side stops, is effective only for small swarms. Larger swarms tend to become congested and confused, and frequently either break through the line of stops or move in circles within the area surrounded by the workers. To avoid this inefficiency and delay, artificial barriers placed at an angle, obliquely to the direction of the drive as in the illustration are employed to replace the stops.



LOCUST BARRIERS.

Metal strips have been used largely for this purpose outside India but are costly, clumsy, and difficult to transport. Lengths of cloth having a six-inch of oil-cloth near the top, and suspended from iron stakes, are equally efficient, more easily placed in position, and readily portable.

The oil-cloth strip is sewn on to a length of material a few inches from the top and a continuous length of stout string is sewn along the top edge of the material. The width of the material for the

screens varies with the nature of the country. Where the screens are to be employed in standing crops (or in areas with high wild vegetation) a width of 42″ to 44″ is needed; this gives a screen three feet high from the ground after allowing six to eight inches to lie on the ground. For bare country or short vegetation a narrower width of cloth would be sufficient. The supports recommended consist of half-inch bar iron, sharpened to a point at the bottom and bent into a loop at the top. These supports are placed firmly into the ground at the required distances, and the screens are stretched tight and suspended from these. **It is important that the suspending rods should be on the opposite side of the screen from the advancing locust band.** They should be of sufficient length to support the screens at the required height, after at least six-inches have been driven into the ground.

Such screens can be quietly and quickly run up where required, without checking the advance of the swarm of hoppers towards the trenches. They completely dispense with the need for side stops, reduce the labour required for driving the swarm, increase the efficiency of each drive, and accelerate control operations. They also reduce the labour expended upon digging, as, in place of a long trench, a deeper broader pit, sufficient to contain the swarm, is dug at the apex of the converging screens.

Locust screens are intended primarily to deal with large swarms of hoppers, and have been issued in units of two hundred and forty yards, made up of ten lengths of twenty-four yards each. One such set, properly disposed, will deal with a swarm frontage of one hundred and twenty to one hundred and fifty yards. For large swarms two or more sets can be combined in a series of angles along the frontage of the swarm.

Method 8.—Traps instead of pits or trenches.

Canvas traps.—Where the subsoil is rocky, or the digging of a pit is otherwise impossible or difficult, a canvas structure in the form of a rectangular open box equal in height to the screens on the two sides and the back, and similarly fitted with American oil-cloth, takes the place of the pit. The hoppers enter it by means of a long, sloping canvas approach at the front. It is efficient, and saves much time and labour in pit digging, but is less simple to erect than the screens. Canvas traps will, however, be essential to locust control by driving, in areas with shallow soil and rocky sub-soil; or if in the hot months the ground is so dry and hard as to be impossible to dig.

Metal box traps.—Sheets of smooth metal can similarly be used to replace digging of pits. The sheets are arranged on the ground in the form of a box. Earth is piled up against the outside to make a road for the locusts to enter.

NOTE ON THE MAINTENANCE OF THE SURFACE OF THE OIL-CLOTH.

If the polished surface of the oil-cloth becomes dirty, it affords a foothold for the locusts and they can climb over it. The slipperiness can be maintained by wiping the surface with a cloth which has been dipped in kerosene oil. This should be done as often as proves necessary.

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